PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 7/34, H04B 17/00

A1

(11) International Publication Number: **WO 98/46026**

(43) International Publication Date: 15 October 1998 (15.10.98)

(21) International Application Number: PCT/SE98/00614

(22) International Filing Date: 3 April 1998 (03.04.98)

(30) Priority Data:
9701273-6 8 April 1997 (08.04.97) SE

(71) Applicant *(for all designated States except US)*: TELIA AB (publ) [SE/SE]; Mårbackagatan 11, S-123 86 Farsta (SE).

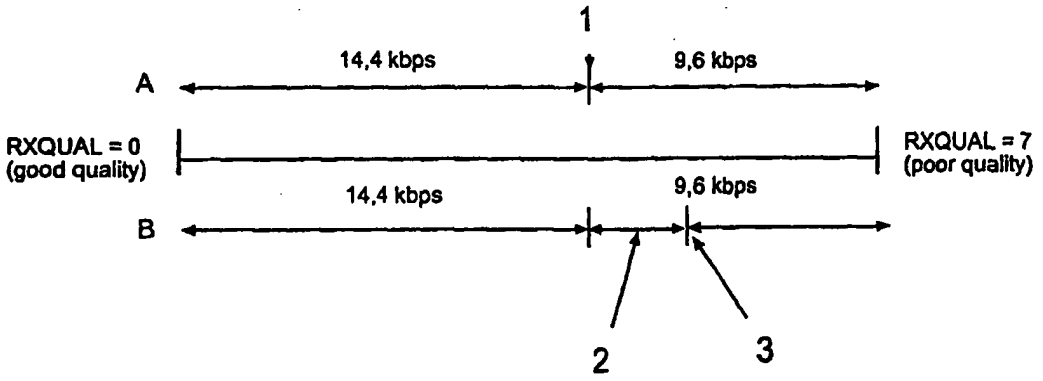
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: WINROTH, Mats, Olof [SE/SE]; Lyckogången 4, S-135 54 Tyresö (SE).

(74) Agent: PRAGSTEN, Rolf; Telia Research AB, Vitsandsgatan 9, S-123 86 Farsta (SE).

(81) Designated States: EE, JP, LT, LV, NO, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: LINK ADAPTION RELATED TO RADIO



(57) Abstract

The invention relates to a method and an arrangement at a wireless, digital, radio communications system which contribute to improving the automatic link adaption, i.e. to, while a call is going on, make it possible to change the channel coding for, for instance, the GSM-services 14,4 kbps and HSCSD. The invention solves this by, at change of channel coding from 14,4 kbps to a more robust channel coding, such as 9,4 kbps, also parameters from RLP, in addition to RXQUAL, are utilized, which also makes possible use of information which describes status of the data transmission link and indirectly real data rate. This will increase the possibilities to, at right point of time, trig a change of channel coding while signal communication is going on between the transmitting and receiving equipments.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

TITLE OF THE INVENTION: LINK ADAPTION RELATED TO RADIO

FIELD OF THE INVENTION

The present invention relates to a method and an arrangement according to the introduction to the patent claim 1 respective patent claim 9.

PRIOR ART

In order to support 14,4 kbps-services in GSM, is required another channel coding than the one which is used today for, for instance, the 9,6 kbps-service. The increased user data rate will have as a consequence that the coded information contains less redundancy, which will result in worse error characteristic. In the case with the 14,4 kbps-service, which has lower error tolerance, the coverage area will by that be smaller, which results in problems at the radio planning. In order to compensate for this problem, an automatic link adaption has been suggested which, while calls are going on, can change the channel coding from 14,4 kbps to, for instance, 9,6 kbps, which is more tolerant to existing errors. Said adaption is intended to be based on the quality parameter RXQUAL which is a mean value estimation of the bit error ratio, which is graded in 8 steps; is described more in detail below.

A problem at the utilization of RXQUAL is that the mean value is a poor measure of the quality of the radio transmission and that certain important parameters for the quality of the data transmission only has an indirect connection to RXQUAL.

The aim with the present invention consequently is to solve this problem.

SUMMARY OF THE INVENTION

This aim is achieved by a method and an arrangement according to the patent claim 1 respective patent claim 9.

The invention consequently attends to that, at change of channel coding from/to 14,4 kbps to a more robust channel coding, in addition to RXQUAL also parameters from RLP, which also allow use of information which describes status of the data transmission link and indirectly real data rate, is utilized.

By, besides using RXQUAL, utilizing RLP, the possibilities consequently are increased to trig a change of channel coding at right point of time while a signal communication is going on between transmitting and receiving equipments.

By parameters from RXQUAL and RLP one covers both real data rate and the quality sphere where the link is beginning to get serious problems.

Further characteristics and embodiments are given in the subclaims.

BRIEF DESCRIPTION OF THE DRAWING

In the following a detailed description is given of an embodiment of the invention with reference to the only drawing.

Figure 1 describes two different models for change to a more robust channel coding in case of poor quality of the radio transmission.

1 Here BSC decides that change of channel coding shall be executed.
2 In this area MSC/RLP decides whether change of channel coding shall be executed.
3 Here BSC decides that change of channel coding shall be executed.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Primarily, change of channel coding by means of RXQUAL will be described. After that the solution of the invention which is based on RXQUAL and RPL will be described.

Figure 1 should be paid attention to during the reading. A in Figure 1 relates to a solution where only the RXQUAL-criterion is utilized. It should be noticed that change of channel coding in A on basis of the RXQUAL-criterion is performed at a value of about 4 of the RXQUAL-scale (RXQUAL=0 to RXQUAL=7). B in Figure 1 relates to the solution of the invention with support for RXQUAL and RLP as criteria. It should be noticed that change of channel coding in B on basis of the RXQUAL-criterion is performed at a value of about 5,5 on the RXQUAL-scale, i.e at a considerably worse value than in A.

It should be realized that these values should not be interpreted literally, but only as examples. Suitable limits to decide when change of channel coding shall be made, must be further investigated. However, the principle to utilize limits for change of channel coding is very important.

In order to simplify the reading, the following acronyms will be explained.

HSCSD:	High Speed Circuit Switched Data
RXQUAL:	Received signal quality
RLP:	Radio Link Protocol
MSC:	Mobile Switching Centre
BTS:	Base Transceiver System
BSC:	Base Station Controller
BER:	Bit Error Ratio
IWU:	Inter Working Unit

In order to support the 14,4 kbps-service in GSM, another channel coding than the one that now is used for, for instance, the 9,6 kbps-service, is required. The

increased user data rate will have as a consequence that the coded information contains less redundance, which results in worse error characteristics. The present data service 9,6 kbps has performance characteristics which fairly corresponds to that of the voice service, i.e. if one can talk, one can almost certainly transmit data. In the case 14,4 kbps, which has lower error tolerance, the coverage area, however, will be smaller, which results in problems at radio network planning. In order to compensate for this problem, an automatic link adaption has been suggested which, while a call is going on, can change the cannel coding from, for instance, 14,4 kbps, which has a weaker channel coding, to the channel coding for, for instance 9,6 kbps, which is more error tolerant. The same procedure is planned for HSCSD.

The link adaption is based on the quality parameter RXQUAL, which MS and BTS measures and forwards to BSC. RXQUAL is an mean value estimation of the bit error rate, BER, during about half a second, and is graded in 8 steps with 0 as the best, and 7 as the worst.

The two big problems with RXQUAL is on one hand the coarse scale, comprising 8 steps, and on the other that RXQUAL and quality does not follow each other for different radio channels.

Only 8 steps give a very coarse picture of the quality of the radio channel. At data transmission in a typical mobile telecommunications channel, at a speed of about 50 km/hour, applies for instance that the data rate is practically unchanged at RXQUAL-values from 0 to 4. Problems will arise only at RXQUAL-values such as 5, 6 and 7.

An hysteresis must be placed to prevent ping-pong-effects from arising and to make sure that the quality really is sufficiently good when one goes from a more robust (lower data rate) to a less robust (higher data

rate) channel coding. When the quality value RXQUAL exceeds a level (i.e. the quality becomes poorer) the channel coding consequently is changed to a more robust one. In order to later change to the "faster" channel coding, 14,4 kbps, again another, and lower, RXQUAL is required. The course classification results in that the hysteresis must be set rather high. Since margins are required, it may result in that a mobile stays unnecessary long time on the slower channel coding if it temporarily has landed up in, for instance, a radio black-out area where channel coding has "changed down."

RXQUAL as a mean value is a poor measure of the quality of the radio communication. At the vehice speeds of, for instance, 50 and 3 km/h, fading dips will be of different lengths. At the higher vehicle speed, they will be short, which results in that the interleaving in the coding can spread the errors sufficiently enough to make it possible to correct them. At the lower speed, fading dips, however, are more seldom occurrent, but are so long that the interleaving will not manage to spread the errors sufficiently. In spite of the fact that the data transmission quality will be very different, BER and RXQUAL, however, in average can be the same for the two cases. When frequency jumps are used, these differences are somewhat reduced.

Important parameters which deal with status of the data communication, such as real data rate, buffers and retransmissions of RLP-frames (Radio Link Protocol, HDLC-similar, bitoriented protocol between interworking functions in MS and MSC) only has indirect connection to RXQUAL.

At a classification of RXQUAL which is temporarily poor, it is conceivable that the RLP-connection still is in fair condition. There is in other words a risk that one changes channel coding earlier than what is motivated for

transmission reasons, which may imply that one unnecessarily changes channel coding and introduces unnecessary delays in the transmission and load in the network.

The RXQUAL-values, or levels, which are described after this, consist of a filtered value which consists of an averaging of a number of RXQUAL-values, which are measured by BTS and MS about twice a second.

At change of channel coding from 14,4 kbps to a more robust channel coding, also parameters from RLP, in addition to RXQUAL, shall be used. Use of information which describes status of the data transmission link, and indirectly real data rate, can improve the possibilities to, at right point of time, trig a change of channel coding.

BSC, which makes up measuring reports from MS and BTS, checks via RXQUAL radio quality and initiates change of channel coding at poor quality by signalling a request for change of channel coding to MSC. As has previously been described, the measure of quality which is obtained from RXQUAL is fairly uncertain when it comes to judging the quality of the data link. In order to avoid "ping-pong change of channel coding" an hysteresis is introduced. In order to further secure that no channel coding is unnecessarily "changed down", information from RLP can be used.

The first RLP-parameter to be investigated is "Transmission attempts" (or a corresponding timer which runs from the expected time of arrival of a frame, until the frame really arrives correctly). The parameter describes the maximal number of times that an RLP-frame can be retransmitted (or, for instance, the time delay for a still not arrived, expected frame in this scheme) without special measures being taken. It can for instance be mentioned that the default setting of the RLP-parameter N2 of the GSM-specifications is six. This means that if a

frame cannot be transmitted or received in the course of six attempts, the RLP-buffers are set to zero or the connection is broken. In order to find out suitable parameter setting to optimize the data rate, simulations are required, but a level of less than 6 frames may be regarded as reasonable.

Another parameter which, in combination with the above, should be used is the total number of retransmissions during a certain period of time. This parameter is strongly connected to real data rate. On the receiving side, a corresponding value can be calculated by checking how many frames that are received correctly, and compare it with the expected number.

With this two parameters one consequently covers both real data rate and the quality domain where the link starts getting serious problems.

In the first place the RLP-parameter criterion is used to "change down", but the RXQUAL-criterion can still be used as the standardized basic solution. The difference, in comparison with the standard solution where BSC decides about change of channel coding, is that now also MSC/IWU can initiate change of channel coding.

At use of the RXQUAL/RLP-criteria, the following apply:

The RXQUAL-criterion is set to a level for lower quality than the RXQUAL-level in a solution without RLP-support. This means that if the quality becomes very poor, the BSC will attend to the change of channel coding (see B in Figure 1).

The RLP-criterion operates between these two RXQUAL-levels (see A, B in Figure 1). MSC decides about change of channel coding.

The information about the state of RLP now is to be found in MS and MSC, but the information in MSC is sufficient, because MSC is the instance which in the normal case initiates and decides about change of channel coding. It should, however, be realized that also MS shall be able to take decision regarding upgrading or downgrading of data rate.

The information about status for RLP is to be found in the IWU and the MSC. This means that information about RLP-status must be conveyed from IWU to MSC. This interface is proprietary, so it need not be standardized.

In a later phase, when we will find more stand alone IWU-functionality, for instance stationed in a GPRS-node, the concept possibly may be necessary to standardize, and that is not impossible because interface between MSC and such a GPRS/IWU-solution still is far from defined. This very day is discussed that an SIWF (Shared Inter Working Function) might be located to a GPRS SN (General Packet Radio Service Node).

If the change of channel coding has been executed to a more robust channel coding due to poor radio channel, but the channel again will improve, RXQUAL must in the first place be used for trigging of resetting to the higher data rate of the channel coding. A similar procedure as the above can of course also be used here, but because it is not certain that the channel coding of the higher data rate will function well when the more robust channel coding does it, the criterion wil be somewhat weaker in this case. It is, however, likely that some gain would be attained, because the hysteresis between "up- and down changes" of the channel coding probably might be possible to cut down a bit. The less hysteresis, the more optimized data rate.

One advantage of the solution of the invention is that standardization with greatest certainty is not needed to have it implemented. This is due to the fact that the only

new signalling that is required is between IWF and MSC, the interface of which is not standardized.

The above mentioned is only to be regarded as an advantageous embodiment of the invention, and the extent of protection of the invention is only defined by the following patent claims.

PATENT CLAIMS

1. Method at a wireless, digital radio communications system to, while communication is going on between a transmitting unit and a receiving unit, execute an automatic link adaption which changes the channel coding of the communication to another channel coding to keep up good signal quality and high transmission rate, c h a r a c t e r i z e d in that at said change of channel coding (B) is utilized on one hand an RXQUAL-criterion, and on the other an RLP-criterion.

2. Method according to patent claim 1, c h a r a c t e r i z e d in that the RXQUAL-criterion is utilized to find out the radio quality in said communication, at which said criterion is the base for the change of the channel coding (B) at poor radio quality, where the radio quality is defined on a scale from RXQUAL=0 (good quality) to RXQUAL=7 (poor quality), and that the RLP-criterion relates to status in said communication and data rate in said communication.

3. Method according to patent claim 2, c h a r a c t e r i z e d in that a first RLP-parameter aims at investigating transmission attempts, at which said parameter describes the maximal number of times that an RLP-frame is allowed to be retransmitted without measures being taken.

4. Method according to patent claim 3, c h a r a c t e r i z e d in that if an RLP-frame cannot be transmitted or received during just any selected number of attempts, change of channel coding can be executed.

5. Method according to patent claim 3 or 4, c h a r a c t e r i z e d in that a second RLP-parameter, in combination with said first RLP-parameter, is used to find out the total number of retransmissions during a certain period of time, at which said second RLP-parameter is associated to data rate.

6. Method according to any of the previous patent claims, c h a r a c t e r i z e d in that said RLP-parameters are used to "change down" from high to low rate.

7. Method according to any of the patent claims 1-5, c h a r a c t e r i z e d in that said RLP-parameters are used to "change up" from low to high rate.

8. Method according to any of the patent claims 1-6, c h a r a c t e r i z e d in that, if change of channel coding has been made to a low rate, for instance 9,6 kbps, due to a poor radio channel, but the channel again becomes better, the RXQUAL-criterion is utilized for resetting to the higher data rate of the channel coding, for instance 14,4 kbps.

9. Arrangement including at least a BSC, MS, BTS and MSC/IWU at a wireless, digital, radio communications system to, while a communication is going on between a transmitting unit and a receiving unit, change the channel coding of the communication to another channel coding by automatic link adaption to maintain good signal quality and high communication rate, c h a r a c t e r i z e d in that said change of channel coding is effected by said BSC on basis of an RXQUAL-criterion or by said MSC/MS on basis of an RLP-criterion.

10. Arrangement according to patent claim 9, c h a r a c t e r i z e d in that said BSC which makes up measuring reports from MS and BT, checks, via RXQUAL, the radio quality of said communication, and initiates change of channel coding at poor quality, at which radio quality is defined on a scale from RXQUAL=0 to RXQUAL7.

11. Arrangement according to patent claim 10, c h a r a c t e r i z e d in that said MSC/MS decides about change of channel coding on basis of RLP-parameters such as 1) transmission attempts, and 2) total number of retransmissions during a certain period of time.

12. Arrangement according to patent claim 11, c h a r a c t e r i z e d in that said MSC/MS on basis of said RLP-parameters preferably executes change of channel coding from high to low rate.

13. Arrangement according to patent claim 11, c h a r a c t e r i z e d in that said BSC, on basis of said RXQUAL, is arranged to reset the channel coding to the channel coding of the higher data rate if the radio quality improves.

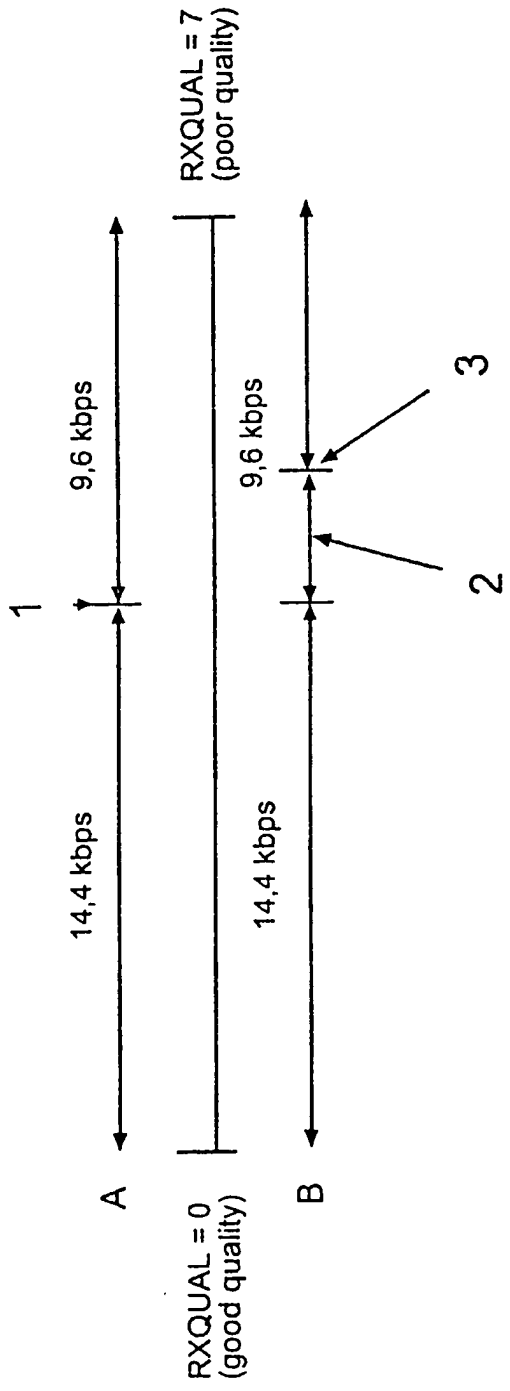

RXQUAL = 7
(poor quality)
9,6 kbps
9,6 kbps
3
2
1
14,4 kbps
14,4 kbps
A
B
RXQUAL = 0
(good quality)

Figure 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/00614

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04N 7/34, H04B 17/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04N, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5070536 A (RONALD L. MAHANY ET AL), 3 December 1991 (03.12.91), column 16, line 13 - line 34; column 17, line 39 - line 47; column 26, line 45 - line 52	1-13
A	GB 2297885 A (NEC CORPORATION), 14 August 1996 (14.08.96), abstract	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 July 1998	21-07-1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bengt Romedahl Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/06/98

International application No.
PCT/SE 98/00614

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5070536 A	03/12/91	US 5483676 A	09/01/96
		US 5673031 A	30/09/97
		AU 632055 B	17/12/92
		AU 3927889 A	08/02/90
		CA 1316218 A	13/04/93
		EP 0353759 A	07/02/90
		GB 2223914 A,B	18/04/90
		US 4910794 A	20/03/90
GB 2297885 A	14/08/96	AU 4449096 A	22/08/96
		CA 2169332 A	14/08/96
		GB 9602964 D	00/00/00
		JP 2693922 B	24/12/97
		JP 8223107 A	30/08/96